

THE APPLICATION OF GLUTARALDEHYDE TO TANNING BELLY WORK GLOVE LEATHER*

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ABSTRACT

Belly work glove leather was produced by glutaraldehyde-chrome combination tannages. The finished leathers were compared to commercially produced chrome leather in chemical composition: moisture, fat, ash, chromic oxide and nitrogen; and in physical properties: shrinkage temperature, tensile strength, Mullen grain crack, and apparent density. The data obtained indicated that glutaraldehyde retannage of chrome-tanned leather produced the best experimental work glove leather. Serviceability was improved, as measured by resistance to deterioration from artificial perspiration.



INTRODUCTION

In recent years more bellies have become available in the pickle. When the width is adequate, many are processed into work glove leather. Earlier investigators (1-8) demonstrated that glutaraldehyde, as the only tanning agent or in combination with chrome, imparts mellowness, perspiration resistance and alkali resistance to leather. In addition, the use of glutaraldehyde in the tannage produces a leather that retains much of its softness and mellowness upon repeated wet-dry cycles. These properties are desirable in work glove leather.

This paper presents studies of belly work glove leather produced by five procedures using glutaraldehyde in combination with chrome.

EXPERIMENTAL

A brief procedure for each tannage is given below. All chemicals were based on the drained pickled weight of the hide or the drained blue weight of the grain splits. A 200 percent float was used. Half-bellies were used to decrease the possibility of the bellies tying together. One percent raw neatsfoot oil was added to all tannages of pickled half-bellies to further minimize this possibility. This helpful suggestion was given us by a visiting chemist.

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Glutaraldehyde Retannage of Commercial Chrome-tanned Bellies.—

Lots of twelve commercially-tanned half-bellies, split to weight "in the blue," were drum-retanned with ten percent glutaraldehyde (25 percent aqueous solution), at a starting temperature of 140°F. (60°C.). The pH was adjusted to 3.8, and the retannage continued for 2½ or 4 hours. A shorter time would be satisfactory on a tannery scale because of better control of temperature. The temperature of the retanning solution had dropped to 109°F. (43°C.) by the end of the retannage. The leather was washed and held for commercial processing into finished leather.

Glutaraldehyde Retannage of Laboratory Chrome-tanned Bellies.—

Twenty-four pickled half-bellies were tanned in approximately 28 hours with ten percent of a 33 percent basic chromium sulfate by a standard chrome tanning procedure. The final pH was 3.9. The half-bellies were drained, wrung, split and shaved to 3¼ to 3½ oz. Twelve were retanned with ten percent glutaraldehyde at a starting temperature of approximately 150°F. (66°C.). The temperature of the retanning solution had dropped to 109°F. by the end of the 2½ to 3 hour retannage. This combination tannage was later repeated on another lot of twelve pickled half-bellies. The other 12 half-bellies were processed into finished leather without retanning, for Laboratory chrome-tanned controls.

Simultaneous Glutaraldehyde-Chrome Tannage.—In this tannage lots of 12 pickled half-bellies were drum-tanned simultaneously with six percent glutaraldehyde and three percent of a 33 percent basic chromium sulfate in 24 hours by the standard chrome tanning procedure. The glutaraldehyde tanning was slow at pH 3.8. Therefore, to prevent streaking, the drum was run intermittently, about five minutes every hour, during the night.

Glutaraldehyde Tannages-Chrome Retannage.—Lots of 12 pickled half-bellies were drum-tanned with ten percent glutaraldehyde for 24 hours at pH 8.0. Sodium sulfate was used to repress swelling. The pH of the tanning liquor in this glutaraldehyde tannage was raised in three or four increments from 2.7 to 8.0 with sodium bicarbonate. There was no noticeable odor of glutaraldehyde at the end of the working day. The drum was run continuously during the day and allowed to stand overnight. The fact that the leather was not streaked was an indication that there was no appreciable amount of glutaraldehyde left at the end of the previous day. The leather was washed, acidified to pH 4.0, and retanned with four percent of a 33 percent basic chromium sulfate in seven hours. One lot of 12 pickled half-belly grain splits was drum-tanned with ten percent glutaraldehyde at pH 4.0 similarly to the simultaneous tannage, but without chrome. Sodium sulfate was used to repress swelling. The leather was washed and retanned with four percent of a 33 percent basic chromium sulfate in seven hours.

Finishing.—All tanned leathers were processed with regular production packs into finished 3 to 3½ oz. work glove leather. A total of 24 commercial chrome-

tanned half-bellies, finished into work glove leather with the retanned stock, were used as controls.

CHEMICAL AND PHYSICAL TESTS

Glutaraldehyde determinations were made on the liquors after tanning by the iodometric method of Fein and Harris (9) and on the finished leather by the method of Korn and Filachione (10).

Chromic oxide, fat (chloroform extracted), nitrogen, ash, moisture, and pH were determined on the finished leathers using the Official Methods of the ALCA (11).

Apparent density, tensile strength, slit tear and Mullen grain crack were determined on the finished leathers using the ALCA-ASTM Methods (12). Shrinkage temperatures were determined on the finished leathers. Those temperatures above 212°F. were determined in water under pressure (13).

Perspiration Tests.—An accelerated artificial perspiration test was conducted following the Tentative Method of Measuring Resistance of Chrome-Tanned White Shoe Upper Leather to Artificial Perspiration (12), using a modified artificial perspiration solution. Twenty grams of urea per liter of solution were used instead of 1.67 grams, given in the method. This was the amount of urea used in a synthetic perspiration solution on both chrome and vegetable-tanned leathers by Gustavson (14). This was the only modification made in the method.

To evaluate the action of artificial perspiration on these leathers in a test somewhat more analogous to deterioration during wear, an alternate soaking-drying test was conducted. Four half-bellies from a tannage were tested. Leather samples 3" x 6" or in some cases 3½" x 6" were soaked for one hour in approximately ten times their weight of water or artificial perspiration solution at room temperature. The samples were next blotted lightly on paper towels to remove excess water or solution and hung to dry for 17 hours in a convection oven at 104°F. The test was run for 12 cycles. Before the test and after 3, 6 and 12 cycles, a specimen one cm. wide was cut from the test sample, along the shorter side, and adjacent to the previously cut one cm. wide specimen. Torsion stiffness measurements were made on these test specimens, using a Williamson torsion instrument modified for leather by Witnauer and Palm (15). Apparent stiffness was calculated in pounds per square inch. Shrinkage temperatures were determined on the same specimens following the stiffness measurements.

RESULTS AND DISCUSSION

The finished leathers were mellow and soft, and in most cases had a good color, "feel" and stretch or "run." The glutaraldehyde-retanned and simultaneously glutaraldehyde-chrome-tanned leathers compared favorably with the

control in these properties. The glutaraldehyde leather tanned at pH 8.0 and retanned with chrome was somewhat darker in color and not quite as smooth and soft in feel as the other leathers. The grain was more open.

Glutaraldehyde utilization was calculated from the difference between the glutaraldehyde present at the start of the tannage and the amount remaining in the tanning liquor at the end of the tannage. We are aware that not all of the glutaraldehyde that disappears from the liquor is fixed in the leather. However, the method is valid for comparative purposes and gives a reasonable approximation of the glutaraldehyde uptake. The utilization is best when tanning with glutaraldehyde at pH 8.0. It was about 96 percent. When tanning or retanning at a pH near 4.0 the reaction is slower. During both of these procedures using ten percent glutaraldehyde, the utilization was approximately 60 percent. During the simultaneous tannage with six percent glutaraldehyde, the utilization was approximately 85 percent.

The chemical and physical data appear in Tables I, II, and III.

The chromic oxide content of these leathers varied from 1.6 to 2.9 percent. The shrinkage temperature ranged from 196° to 217°F. This is high enough to prevent shrinkage when the gloves are shaped during manufacture and compares favorably with the shrinkage temperature of the control leathers.

The fat content is high, to produce a soft stretchy leather. The leather has been drummed with talc to produce an unctuous feel, which causes the ash to be high. The commercial chrome-tanned leather retanned with glutaraldehyde was similar in composition to the commercial control leather.

The tensile strength of the leathers varied from tannage to tannage and did vary considerably from belly to belly within a given tannage. The data in Table II are average values, in most cases involving 36 tensile strength measurements. There are several factors which are known to influence the tensile strength of leather. Retannage, over-tannage, and variations in thickness after splitting, may tend to weaken the leather.

The bellies tanned with chrome and those tanned with chrome and retanned with glutaraldehyde had the highest tensile strength. These were split "in the blue." The leathers tanned simultaneously, and those tanned with glutaraldehyde first and retanned with chrome, had considerably lower tensile strengths. The simultaneous tannages and the ones tanned with glutaraldehyde first at pH 8.0 were split after the final tannage. It was suspected that glutaraldehyde as the first tannage or in a simultaneous tannage with chrome produces a fluffier, thicker, and more open leather. Therefore, when this leather is split to 3-3½ oz. for grain leather, more of the corium is cut away than when splitting a thinner, more compact leather.

To determine the correctness of this assumption, apparent densities were determined on these belly work glove leathers. The leathers are similar in chemi-

TABLE I
COMPOSITION OF THE LEATHER

Leather	Moisture %	Fat* %	Nitrogen* %	Ash* %	C ₂ O ₃ * %	Glutaraldehyde* mg./g. Protein	pH	Ts °F.
Controls								
Commercial Chrome								
1	6.0	20.2	10.4	9.7	2.0	—	4.1	199
2	5.5	23.3	9.6	11.0	1.9	—	4.0	193
Laboratory Chrome								
1	11.2	24.2	9.2	12.0	2.7	—	4.3	210
Glutaraldehyde Retan of:								
Commercial Chrome								
1	5.8	19.1	10.2	10.2	2.0	20	4.0	207
2	10.4	17.9	10.5	10.2	2.2	26	4.1	210
3	4.8	20.5	10.0	9.2	2.0	27	4.1	199
Laboratory Chrome								
1	4.4	19.8	9.7	11.2	2.7	43	4.4	217
2	10.8	22.9	9.3	11.6	2.9	—	4.4	217
Simultaneous Glutaraldehyde-chrome								
1	6.1	19.5	10.3	10.9	1.6	27	—	196
2	9.7	20.9	10.0	11.2	1.6	27	4.2	199
Chrome Retan of:								
Glutaraldehyde at pH 4.0	10.0	19.8	10.0	10.9	1.9	41	4.3	203
Glutaraldehyde at pH 8.0								
1	5.9	18.9	10.1	10.7	1.9	50	4.4	201
2	9.9	20.2	9.6	11.1	2.0	57	4.3	207

*All results on a moisture-free basis.

TABLE II
PHYSICAL PROPERTIES OF THE LEATHER

Leather	Apparent Density* gm./cm. ³	Tensile Strength† PSI	Slit Tear Strength‡ Load to Tear		Mullen Grain Crack** Load to Crack	
			Parallel lbs.	Perpendicular lbs.	Control lbs.	Perspiration Test lbs.
Controls						
Commercial Chrome						
1	.5883	2430	—	—	345	Failed
2	.5805	2170	20	31	470	Failed
Laboratory Chrome						
1	.5873	3305	33	45	360	200
Glutaraldehyde Retan of:						
Commercial Chrome						
1	.5568	1840	—	—	305	345
2	.5133	1460	—	—	320	330
3	.5609	1910	17	23	308	262
Laboratory Chrome						
1	.5456	2160	28	34	405	420
2	.5843	2880	28	41	560	570
Simultaneous Glutaraldehyde-chrome						
1	.4907	1395	—	—	270	285
2	.4744	1265	—	—	270	240
Chrome Retan of:						
Glutaraldehyde at pH 4.0						
Glutaraldehyde at pH 8.0						
1	.4767	990	—	—	180	210
2	.4797	955	—	—	190	170

*ASTM Method D 2346-65T.

†ASTM Method D 2209-64; the long axis of the specimen was perpendicular to the backbone.

‡ASTM Method D 2212-64.

**ASTM Method D 2210-64.

TABLE III
APPARENT STIFFNESS IN TORSION AFTER REPEATED
SOAKING-DRYING CYCLES

Leather	Cycles				Increase after 12 Cycles psi
	0 psi	3 psi	6 psi	12 psi	
Soaked in Artificial Perspiration Solution					
Commercial Chrome Control	639	1495	2441	2650	2011
Glutaraldehyde Retan of Commercial Chrome	604	1000	1590	1560	956
Laboratory Chrome Control	307	1658	2041	2026	1719
Glutaraldehyde Retan of Laboratory Chrome	308	666	873	1166	858
Soaked in Water					
Commercial Chrome Control	525	855	955	810	285
Glutaraldehyde Retan of } Commerical Chrome }	503 1096	636 1924	607 2039	690 1679	187 583
Laboratory Chrome Control	546	768	748	756	210
Glutaraldehyde Retan of Laboratory Chrome	262	297	241	302	40

cal analysis, and all were finished in the same way. Therefore, for comparative purposes significant differences in apparent densities might indicate differences in leather structure and character. This might also indicate variations in thickness of the corium layer after splitting, with resultant differences in tensile strength (16).

The data indicate a general trend. The tensile strength of the leathers increased as the apparent densities increased (Figure 1). The simultaneously tanned leathers and those tanned with glutaraldehyde first had the lowest apparent densities and these were considerably lower than those of the other leathers. This is evidence that more hide substance may have been split away from the simultaneously tanned bellies and from those where glutaraldehyde was the first tannage.

In most cases, on repeated lots or the same tannage, the data indicate a directly proportional relationship between the tensile strength and apparent density. This can be noted from Table II. The variation in tensile strengths is due to fiber count, which causes a variation in hide substance and therefore in strength when splitting and shaving to 3-3½ oz. The lowest values were recorded for leather pretanned with glutaraldehyde on the alkaline side.

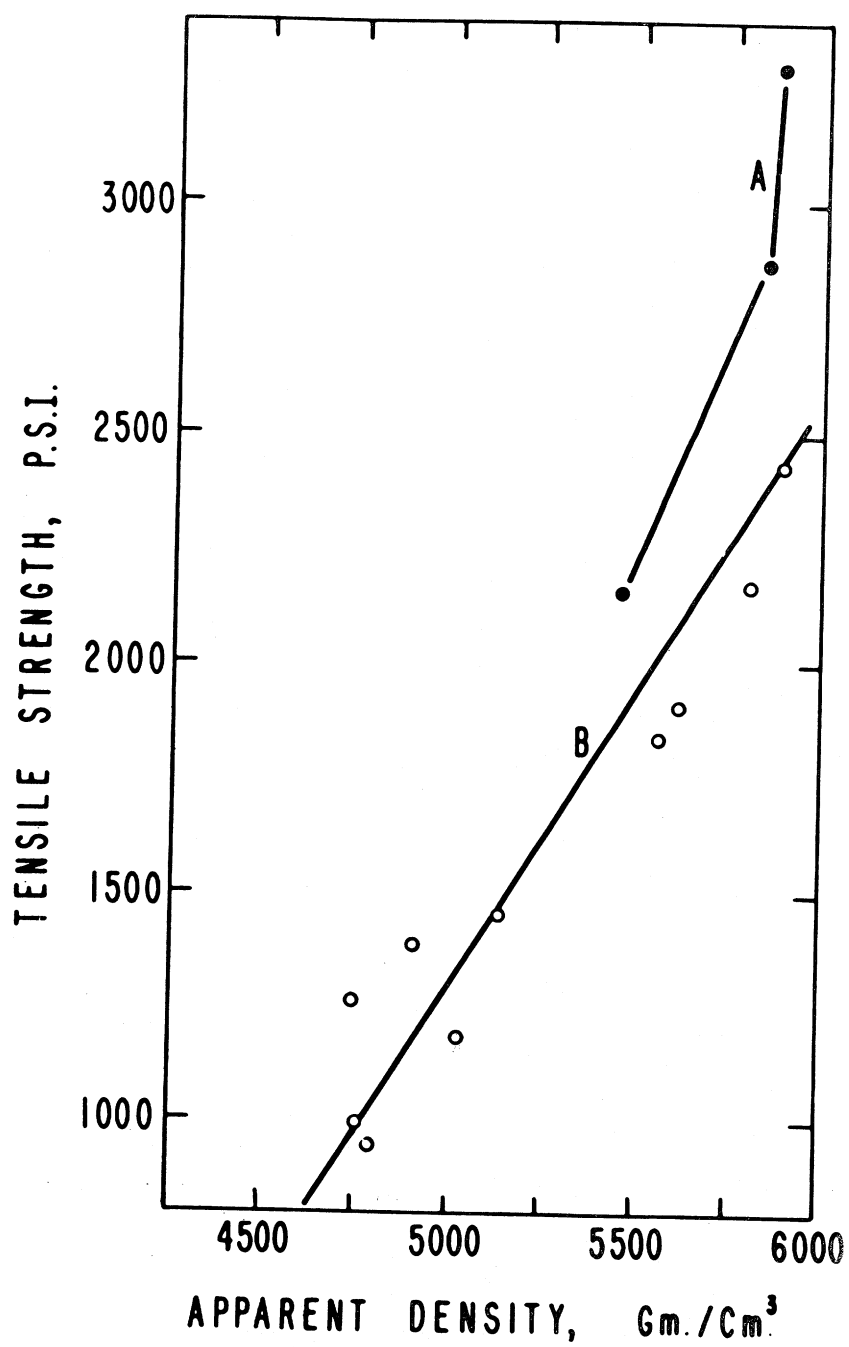


FIGURE 1.—Graph showing the relationship between tensile strength and apparent density of work glove leathers. A — Leathers analyzing 2.7 to 2.9% Cr₂O₃; B — Leathers analyzing 1.6 to 2.2% Cr₂O₃. (Apparent density values should be divided by 10⁴ so that the values range from 0.45 to 0.60.)

RESISTANCE TO DETERIORATION

Accelerated Perspiration Test.—The leathers tanned with glutaraldehyde in combination with chrome had better resistance to artificial perspiration than commercial chrome-tanned leather (Figure 2). The chrome-tanned leather which analyzed two percent chromic oxide failed the test. It became badly shrunk, dark in color and hard. After retannage with ten percent glutaraldehyde it showed greatly improved resistance to perspiration. Even after being subjected to the conditions of the test, the retanned leather was soft and flexible with only slight changes in color and a small loss in area.

Another commercial chrome-tanned leather which analyzed 3.7 percent chromic oxide also deteriorated (Figure 2, center specimen).

The Mullen grain crack data (Table II) indicate that the grain of most of the chrome-glutaraldehyde leathers was not weakened significantly by the perspiration test. In most cases the load to crack was slightly higher after the perspiration test than it was on the original leather. This increase is probably within experimental error. One of the glutaraldehyde-retanned leathers showed a 15 percent decrease in grain crack and two other combination leathers, one simultaneously tanned and one glutaraldehyde-tanned, chrome-retanned, each showed about an 11 percent decrease. Mullen grain crack measurements could not be determined on the commercial chrome-tanned leathers after being subjected to the test conditions. The laboratory chrome-tanned leather control showed a 44 percent decrease in grain crack.

Repeated Soaking in Artificial Perspiration Solution.—The decrease in the shrinkage temperature of the chrome-tanned control leathers and the glutaraldehyde-retanned leathers after alternate soaking in artificial perspiration solution and drying can be seen in Figure 3. The shrinkage temperature dropped with successive treatments. After 12 cycles, the T_s of the commercial chrome-tanned leather had decreased 61°F. to 131°F. (55°C.). The commercial chrome-tanned, glutaraldehyde-retanned leather showed a shrinkage temperature decrease of 41°F. The shrinkage temperature of the laboratory chrome-tanned leather decreased 72°F. during the test, whereas that of the laboratory chrome-tanned, glutaraldehyde-retanned leather decreased 52°F. In each case the shrinkage temperature of the chrome-tanned control leather decreased 20°F. more than the glutaraldehyde-retanned leather during the 12 cycles of the test.

The artificial perspiration solution gradually reverses the chrome tannage (14, 17, 18). This undoubtedly also happens during wear, but much more slowly. Glutaraldehyde in the tannage apparently slows this detanning process.

The apparent stiffness of the leathers treated with artificial perspiration solution increased rapidly through the first six cycles of the test and then either remained constant or increased more slowly through the last six cycles (Table III).

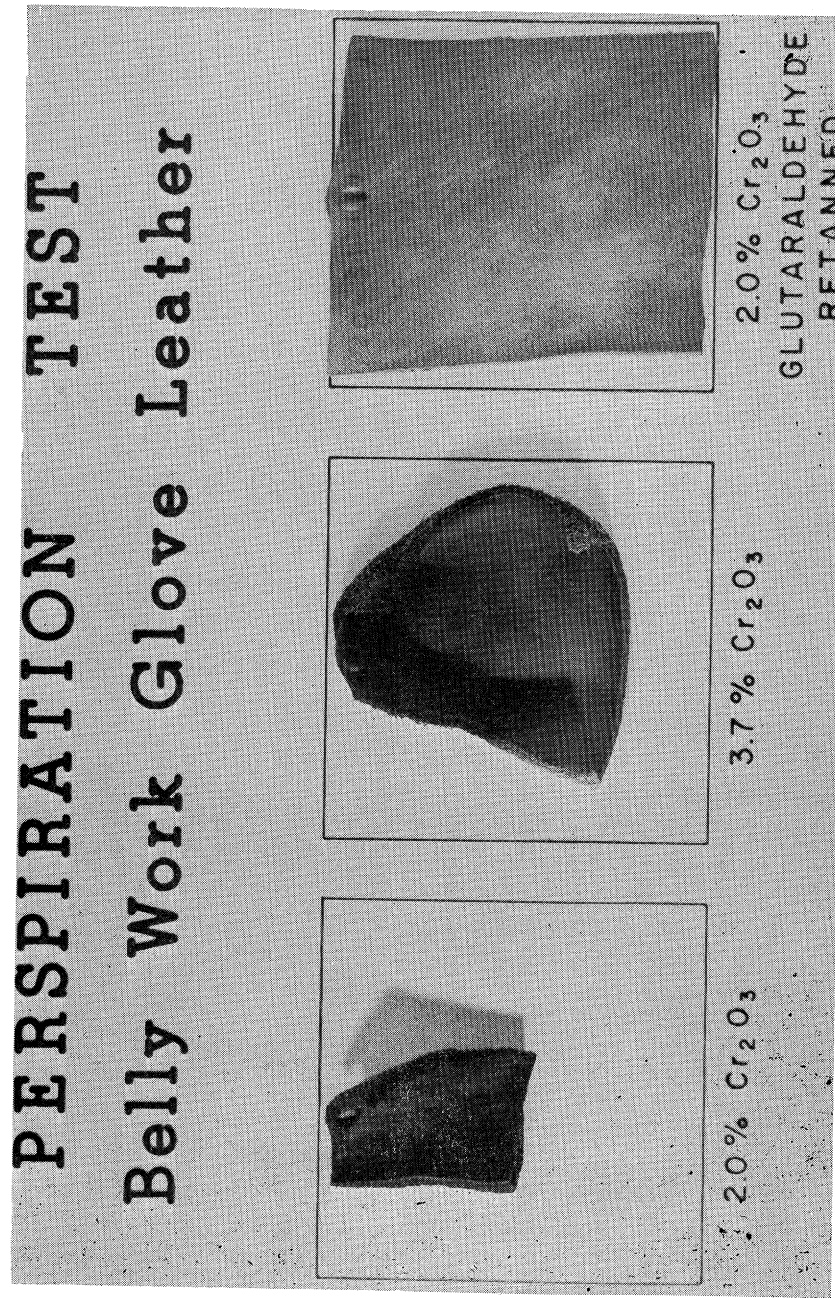


FIGURE 2.—Photograph of two commercial chrome-tanned work glove leathers and a glutaraldehyde-retanned work glove leather after the accelerated perspiration test.

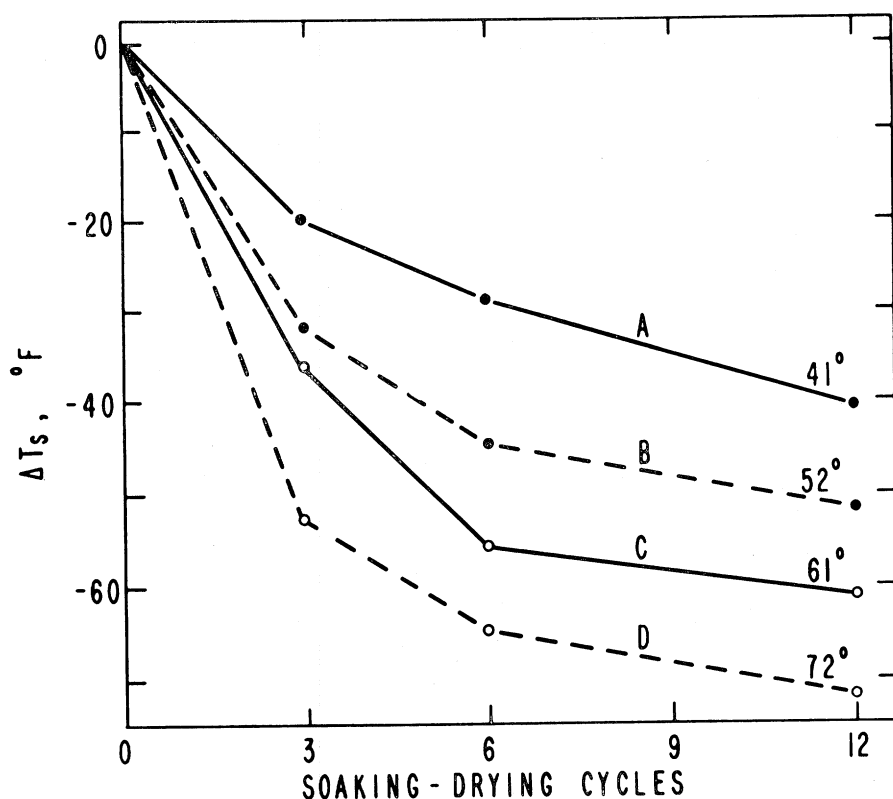


FIGURE 3.—The change in shrinkage temperature of the work glove leathers alternately soaked in perspiration solution at room temperature and then dried at 104°F. A — Commercial chrome-tanned, glutaraldehyde-retanned leather; B — Laboratory chrome-tanned, glutaraldehyde-retanned leather; C — Commercial chrome-tanned control leather; D — Laboratory chrome-tanned control leather.

The laboratory chrome-tanned leathers, control and glutaraldehyde-retanned, were softer leathers and contained more chrome than the commercial chrome-tanned leathers. They stiffened less than their commercial chrome-tanned counterparts during the test.

The leathers tanned with chrome alone showed the greatest increases in apparent stiffness. In each of the two cases there was approximately 100 percent increase over that of the glutaraldehyde-retanned leather. Glutaraldehyde retannage of chrome-tanned leather apparently retards the stiffening of the leather when treated with artificial perspiration.

Repeated Soaking in Water.—Samples of the glutaraldehyde-retanned leathers soaked alternately in water and dried at 104°F., showed only slight changes in shrinkage temperature. The commercial chrome-tanned control showed

a decrease of 6°F. between the 6th and 12th cycles. The laboratory chrome-tanned control showed a rise of 6°F. in 12 cycles.

The apparent stiffness of the leathers alternately soaked in water and dried, increased through the first three or six cycles and then tended to remain constant or decrease slightly (Table III). Except for one case, the data in Table III represents four half-bellies for each leather. It will be noted that there are two sets of data for the glutaraldehyde retan of commercial chrome-tanned leather soaked in water. Each set of data represents two half-bellies. For some unknown reason, one set of half-bellies behaved exceptionally different from the rest. It was originally much stiffer than the other and also stiffened more during the test. In general the glutaraldehyde-retanned leathers tended to show somewhat less stiffening after the water treatment than their chrome-tanned controls.

CONCLUSIONS

The data obtained from this study indicate that glutaraldehyde retannage of chrome-tanned leather produced the best experimental work glove leather. It was similar to the commercial product in appearance. The strength was adequate. The shrinkage temperature was increased and the perspiration resistance was markedly improved.

Fortunately, retanning regular chrome-tanned leather at an elevated temperature is the simplest and most practical procedure.

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DISCUSSION

MR. MAESER: Mr. Shivas, Robson Lang Leathers Company, will lead the discussion.

MR. SHIVAS: Mrs. Happich and her co-workers are to be congratulated for giving such a practical paper. Improved sweat resistance is needed in many leathers, such as shoe linings, sporting goods leathers, etc. so this paper has a very wide application. Apparently sweat resistance can be readily improved without new equipment, complicated procedures, or expensive materials. The drumming times in these laboratory tests were extremely long, but no doubt they would be shortened in full-size factory loads.

Now, in yesterday's John Arthur Wilson Memorial Lecture, Dr. Bradley gave a very complicated method of determining apparent density. How did you determine apparent density?

MRS. HAPPICH: We determined apparent density as the ratio of the mass to the volume. We calculated the volume, using the area and thickness of the test specimen. The thickness was measured on a dead weight thickness gauge.

MR. SHIVAS: Thank you.

In your husband's paper, this morning, he mentioned that glutaraldehyde-plus-chrome leather absorbed more moisture than a straight chrome-tannage. Did you find this in these work-glove leathers too?

MRS. HAPPICH: We didn't determine water absorption on these leathers. We soaked our control samples in water for the perspiration test, but we did not determine how much was absorbed.

MR. SHIVAS: Are there any questions from the floor?

DR. VON FUCHS: Discussion of this paper gives me an opportunity to thank Eastern Regional Laboratories for the cooperation they afforded me for the last year. In my left hand I hold two pieces of leather obtained from them which was lubricated with less than 1 percent of A.S.A. and you will see from the droopiness it's rather soft leather. It is oil lubricated and it floats. Its water pick up in Dr. Seligsberger's tumbling test is less after each wetting, in other words it has a permanent built in water resistance. This leather is highly susceptible to treatment by both silicones and A.S.A. It costs a little more to do it with silicones.

This form of glutaraldehyde retannage was discussed at great length at the first paper presented at Mackinac Island. I still say what I said then, it has a great future, and more power to it.

MR. SHIVAS: Dr. Pepper?

DR. PEPPER: I haven't a question, Mrs. Happich, but I have a comment. You would perhaps be interested to know that we have abundant confirmation in Britain of the value of glutaraldehyde retannage for perspiration resistance. It is fully confirmed that glutaraldehyde imparts a considerable improvement in perspiration resistance.

There is one little warning that I would sound, and it really is obvious from your own tables. You showed that there is a risk with glutaraldehyde retannage of a drop in strength. Now, I would agree that this would not be important in leathers of reasonable weight such as work gloves, but it does become important with some glove leathers of much lower weight. We have run into this difficulty that the glutaraldehyde retannage lowers strength and there is a danger of stitch tear in the making of thin gloves.

The second difficulty we've run into is that glutaraldehyde retannage does reduce the surface abrasion on the glove in wear. This is the sort of thing that could be important in golf gloves, as distinct from work gloves. Thank you.

MR. SHIVAS: Any other questions?

DR. VON FUCHS: Since the gentleman preceding me at the microphone mentioned the strength, I have an opportunity to say that all the old-fashioned leathers not lubricated by A.S.A. should be re-evaluated, because this glutaraldehyde

leather is extremely strong after this lubrication process. If you have proper lubrication which reacts with the fibers, you can overcome the handicap of a tannage which may give you weak fibers. These only need to be plasticized by A.S.A. and you have solved your strength problem, and your abrasion problem.

MR. TRAUB (Robson-Lang): The two most important properties of work glove leathers are stretch and absence of flankiness in the leather. I wonder which of the five experiments you have conducted, compare most favorably with the present commercially-made chrome tanned work glove leathers?

MRS. HAPPICH: The only stretch measurements we have are on the elongation at break during tensile strength measurements, and on extension at grain crack. The chrome-tanned leathers had an elongation of about 70 percent and 83 percent and an extension of about 67 percent and 98 percent. The glutaraldehyde-retanned leathers — in fact, all of the leathers — compared favorably with this.

MR. TRAUB: The other question was color. Was the finished leather level in color?

MRS. HAPPICH: All except the leather which was tanned with glutaraldehyde first and retanned with chrome compared favorably with the chrome-tanned leather in color. All these leathers were dyed.

MR. SHIVAS: Yes?

DR. WALLACE WINDUS (Eastern Regional Research Laboratory): Of course, in regard to the appearance, we were working with belly work glove leather, so we had two flanks, and the leather is not particularly beautiful. The bellies were also rather narrow. Color was satisfactory, as Mrs. Happich indicated, except for the one which was tanned with glutaraldehyde first. That was tanned at a pH of 8, and a higher pH does cause darkening in the color in tanning with glutaraldehyde.

I might mention in connection with the previous comments that we agree with Dr. Pepper that there is some reduction in strength when leather is retanned with glutaraldehyde. As he indicated, this is particularly important on thin leather such as that used for flier's gloves, on which his laboratory is working. This leather must also absorb perspiration readily without deterioration. You do not want a water-resistant leather.

MR. SHIVAS: Yes?

MR. CLINTON RETZSCH (Nopco Chemical Co.): I should like to know the temperatures at which the perspiration resistance tests were run.

I should also like to know whether you have done any work in which you have held glutaraldehyde retanned leather at elevated temperatures with observation of the rate at which shrink temperatures decline.

I think this would be of real interest in the work glove leather field since many of the gloves of this type are used in handling very hot equipment. We have noted in our laboratory that quite often straight chrome tanned leather held in a moist condition at temperatures of 120°-140°F., decreases very rapidly in shrink temperature. If glutaraldehyde would help to prevent this decline in shrink temperature it would be very valuable.

MRS. HAPPICH: Your first question was on the temperature at which we ran our perspiration tests. We followed the method of the A.S.T.M. for the chrome-tanned white shoe upper leather. The wet leather was held at 70°C. for 48 hours. However, we did modify the solution by adding more urea.

In our alternate wetting-drying test using perspiration solution, the wetting was done at room temperature, and the drying at 104°F.

We have not held these leathers at high temperatures, either wet or dry, for longer than 48 hours.

MR. SHIVAS: Any further questions?

MR. DEXTER RISEDORPH (Risedorph, Inc.): Were some of these applications of glutaraldehyde given at a 10 percent and some at a 6 percent level?

MRS. HAPPICH: That's correct. In the retannages, we used 10 percent of a 25 percent aqueous solution of glutaraldehyde. In the simultaneous tannage we used 6 percent glutaraldehyde and 3 percent Tanolin R, and in the glutaraldehyde tannages first, at pH 4 or pH 8, we again used 10 percent glutaraldehyde.

MR. SHIVAS: If there are no further comments, we'll close by thanking Mrs. Happich again for this interesting paper.
